WMO and CGMS Involvement in Space Weather

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Acronyms

- WMO: World Meteorological Organization
- CGMS: Coordination Group for Meteorological Satellites

Outline

- **Why should WMO be involved in Space Weather ?**
  - Is there any interest for WMO to engage in space weather?
  - Is there interest for space weather to engage WMO?
- **WMO activities in space weather**
  - Observation, data exchange
  - Products and services
- **CGMS potential activities in space weather**

- **Conclusions**

World Meteorological Organization in a nutshell

The specialized United Nations agency for meteorology (weather and climate), operational hydrology and related geophysical sciences.

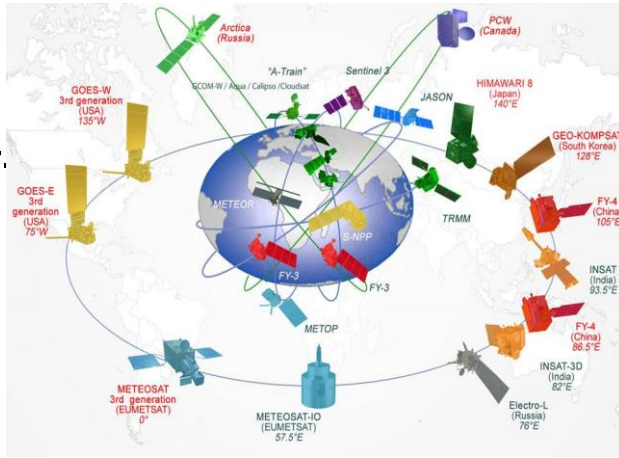
- protection of life and property
- poverty alleviation and economic growth
- sustainable use of natural resources
- environmental quality

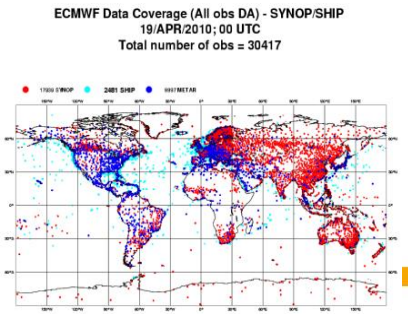
WMO Members include 185 States + 6 territories represented by the Head of their Met Service

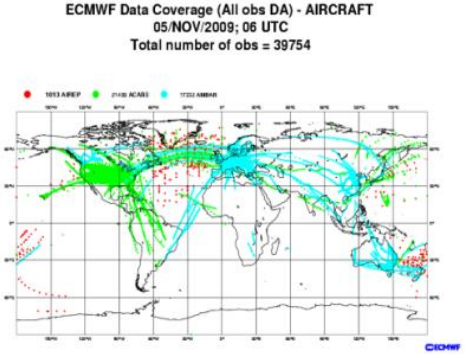
WMO headquarters
Geneva, Switzerland

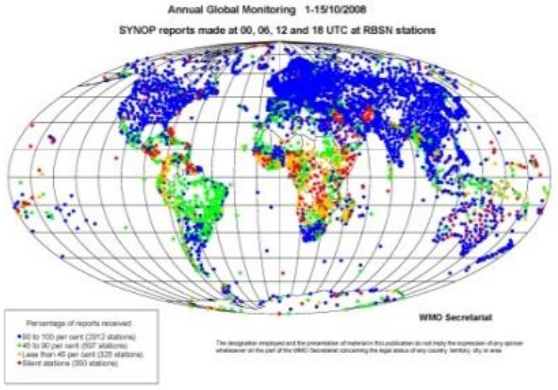
WMO Global Observing Systems (1)

- **Global Observing System of the World Weather Watch** (WWW/GOS)
  - Space-based observing system (Serving all WMO applications)
  - RBSN, RBCN (>10,000 stations,1,000 upper-
  - AMDAR (39754/day)
  - Ship & Marine obs (30417/day)
  - Surface-based remote sensing
  - Meso-scale networks



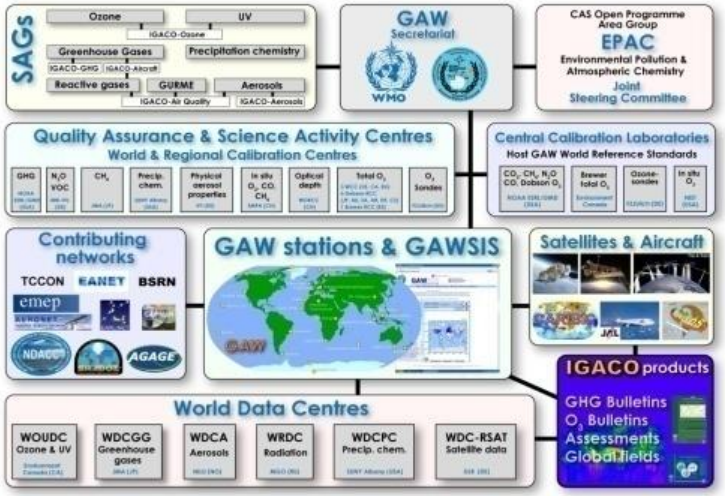


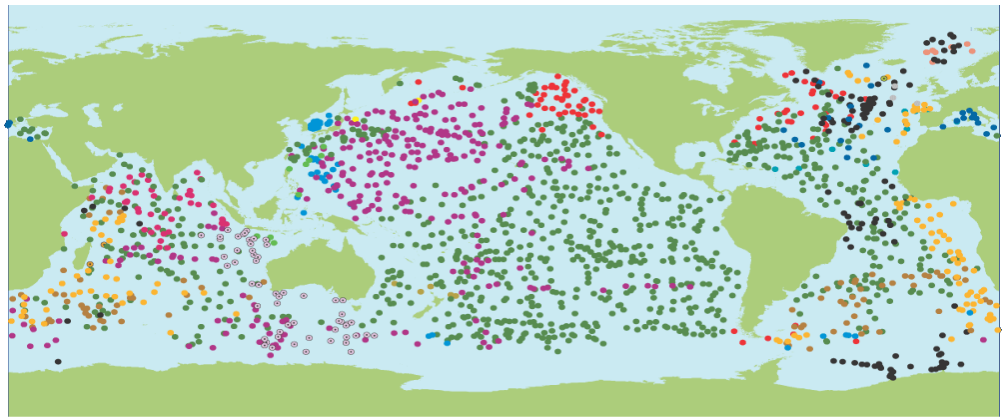


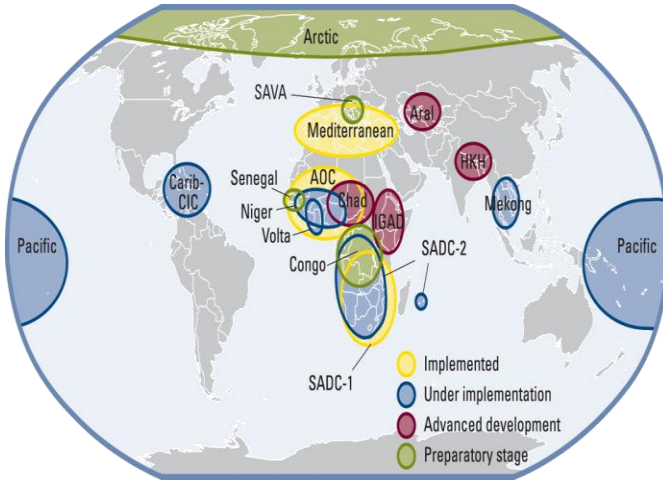


WMO Global Observing Systems (2)

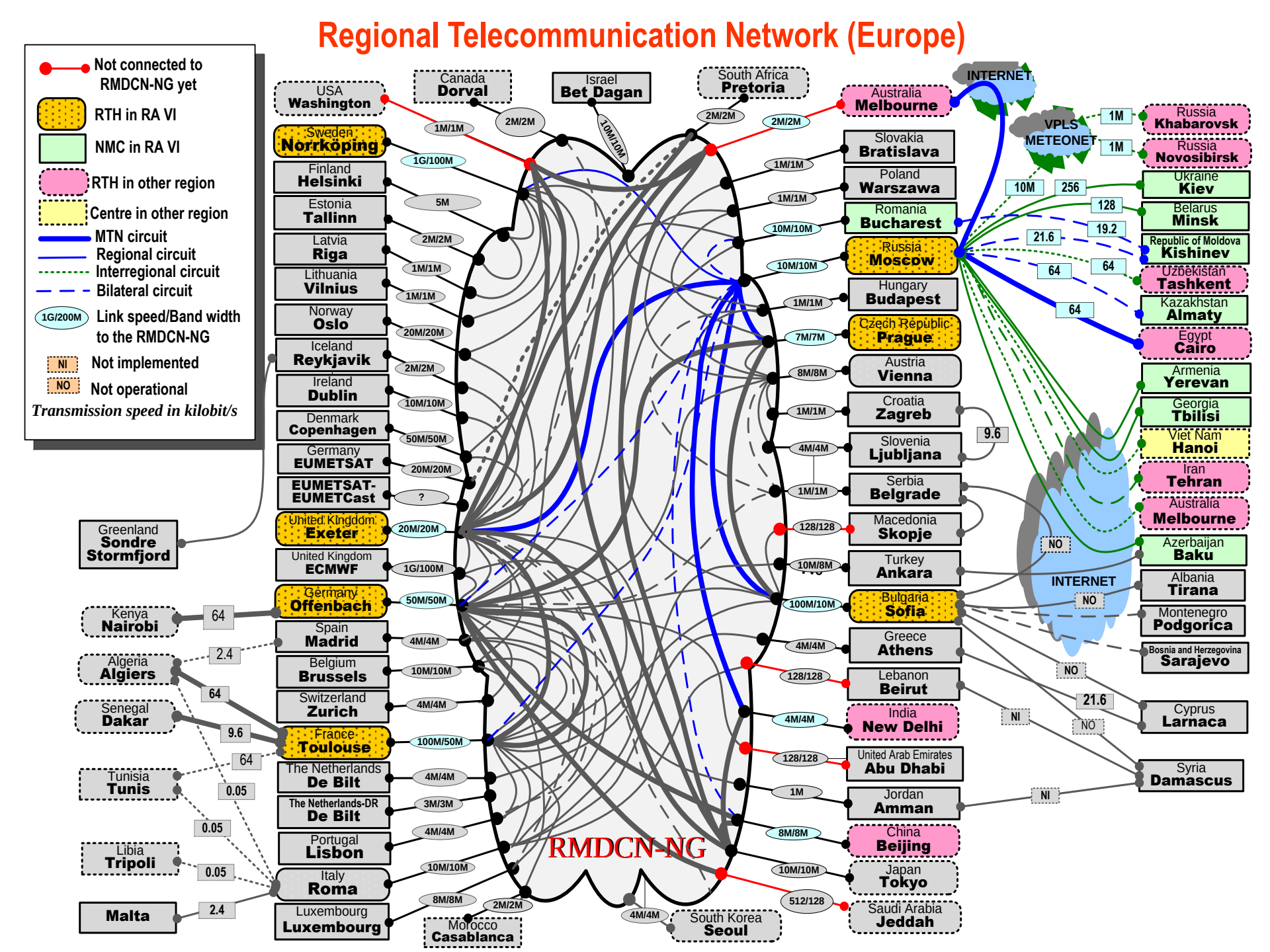
- Global Atmosphere Watch (GAW)
- World Hydrological Cycle Observing System (WHYCOS)
- WMO Co-sponsored Observing System
  - GCOS, GOOS, GTOS
- Striving for integration of these different systems







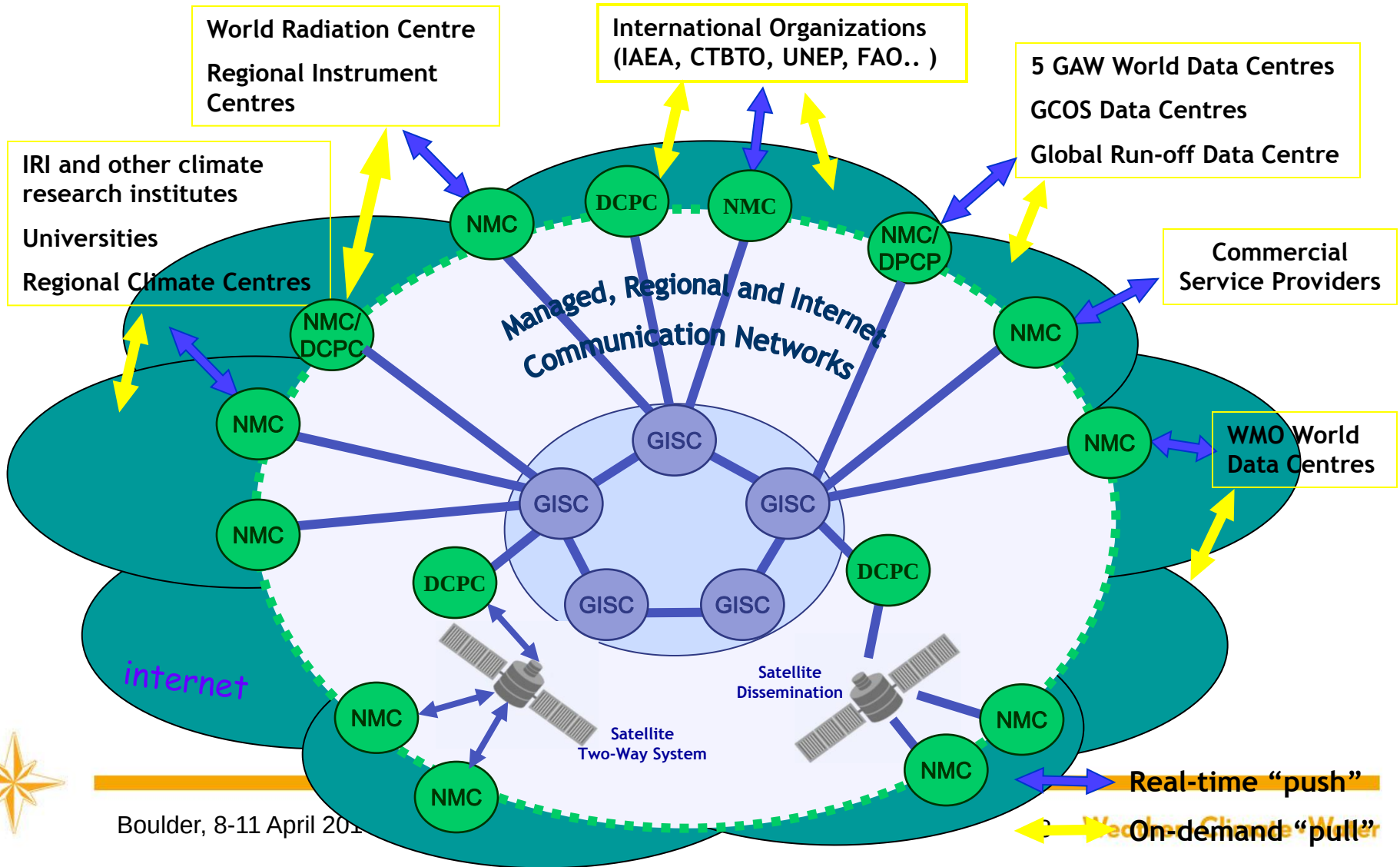
Regional Telecommunication Network (Europe)



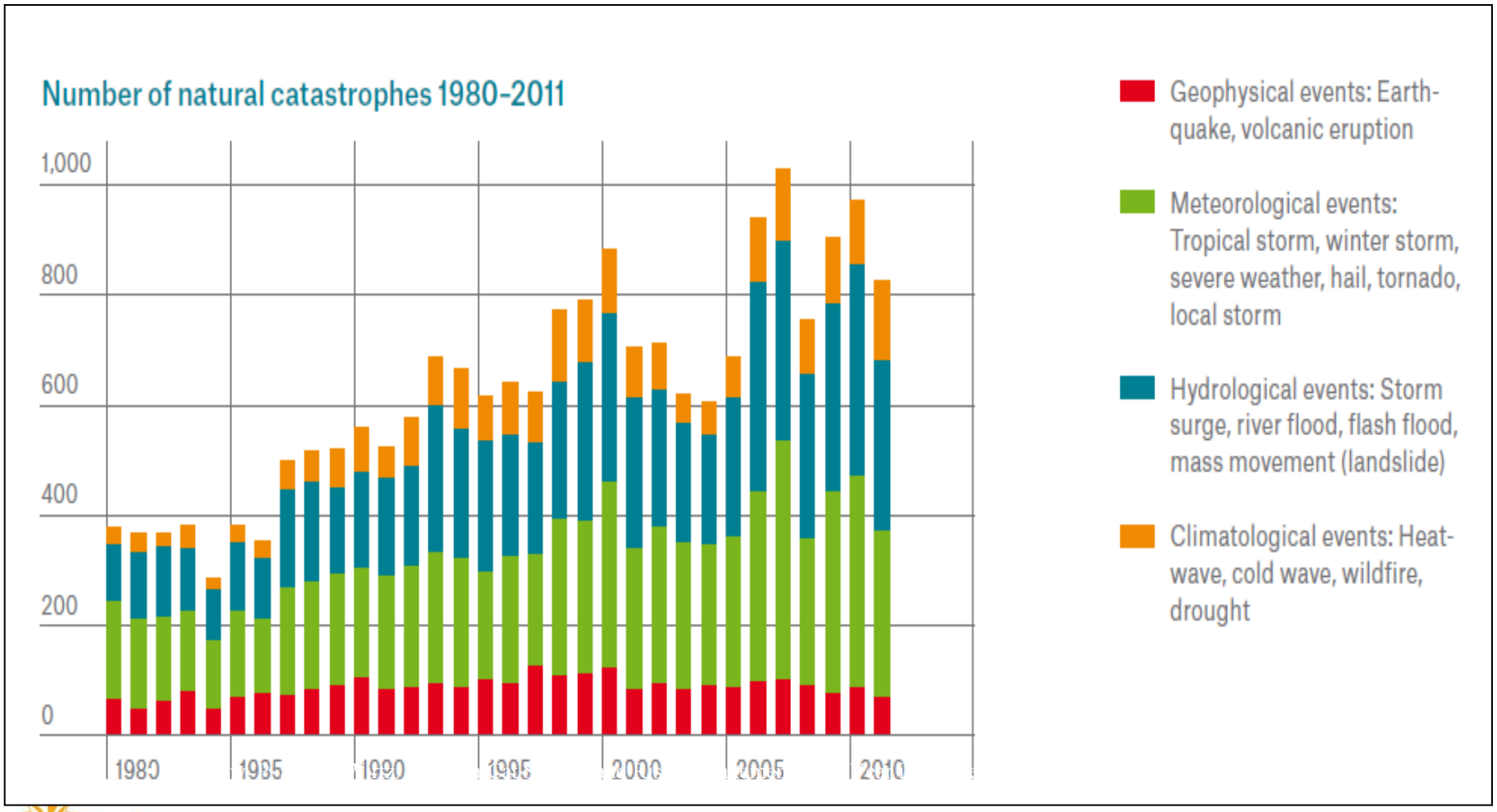
WMO Information System (WIS)

Information exchange – common procedures; real-time and non-real time

Information management – a few standard data formats; coordinated metadata and catalogues



Natural disasters 1980-2011:
90% of the disasters are hydro-meteorological events



Is WMO interested in space weather ?

- Space weather affects meteorological activities
  - Impact on meteorological satellites (90% of observ)
  - Impact on radio-communications used in daily operations
  - Coupling between ionosphere and neutral atmosphere
  - Potential impact on climate

- User or active player ?

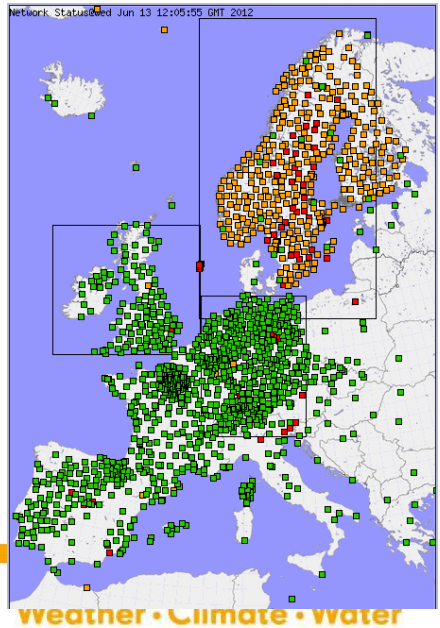
- WMO priorities (2012-2015 Strategic Plan)
  - *Global Framework for Climate Services*
  - *Disaster Risk Reduction*
  - *Integration of global observing and information systems*
  - *Aeronautical Meteorology*
  - *Capacity development*

Can WMO help space weather ? (1)

- To evolve towards fully operational scale
  - Permanent, sustainable, quality-controlled services
  - Delivered to a global audience
  - Globally coordinated within intergovernmental commitments

- WMO's 60-year experience in operational coordination of observation, data exchange, forecasting, warning
  - Global Telecommunication System, WMO Information System…
  - Best practices
  - Dual use of some observations (GNSS)

E-GVAP network



Can WMO help space weather ? (2)

- Key application sectors interested in WMO taking an active role to allow integration of services
  - Global aviation (ICAO-WMO)
  - Emergency management (Multi-hazard warning)
  - Probably others
    - Energy, ground transportation, off-shore…

Decisions by WMO Executive Council and Congress

- In 2008 the Executive Council agreed to set up a an expert team for initial activities in cooperation with ISES, ICAO, ITU, UN (COPUOS)

- In 2011 WMO Members (WMO Congress) confirmed the decision to engage in « **international coordination of *operational* Space Weather observation, products and services, in particular to protect against global space weather hazards** ».

WMO's activities in Space Weather

Inter-Programme Coordination Team on Space Weather (ICTSW)

- Currently 23 countries
  - Australia, Belgium, Brazil, Canada, China, Ethiopia, Finland, France, Germany, Italy, Japan, Norway, Pakistan, Rep. Korea, Russian Federation, South Africa, Spain, Switzerland, Thailand, United Kingdom, USA
- 7 international organizations
  - ESA, ISES, EU/JRC, ICAO, ITU, UN-OOSA, WMO
- Co-chairs
  - **Terrance Onsager** (USA)
  - **Xiaoxin Zhang** (China)
- Governance
  - Commission for Basic Systems
  - Commission for Aeronautical Meteorology

- Mike Terkildsen
- Ronald Van der Linden
- René Warnant
- Clezio de Nardin
- Joaquim Costa
- Larisa Trichtchenko
- Jingsong Wang
- Xiaoxin Zhang
- Alain Hilgers
- Yitaktu Tesfatsion
- Neil Mitchison
- Kirsti Kauristie
- Nicole Vilmer
- Raul Romero
- Sergio Buonomo
- Daniele Biron
- Bruno Zolesi
- Mauro Messeroti
- Mamori Ishii
- Pal Brokke
- Hans Haubold
- Kichang Yoon
- Hyesook Lee
- Muhammad Ameen
- Vyachesloav Burov
- Lee-Anne McKinell
- Werner Schmutz
- Consuelo Cid
- Wirat Waranuchit
- David Jackson
- Joe Davila
- Mangala Sharma
- Terry Onsager
- Jerome Lafeuille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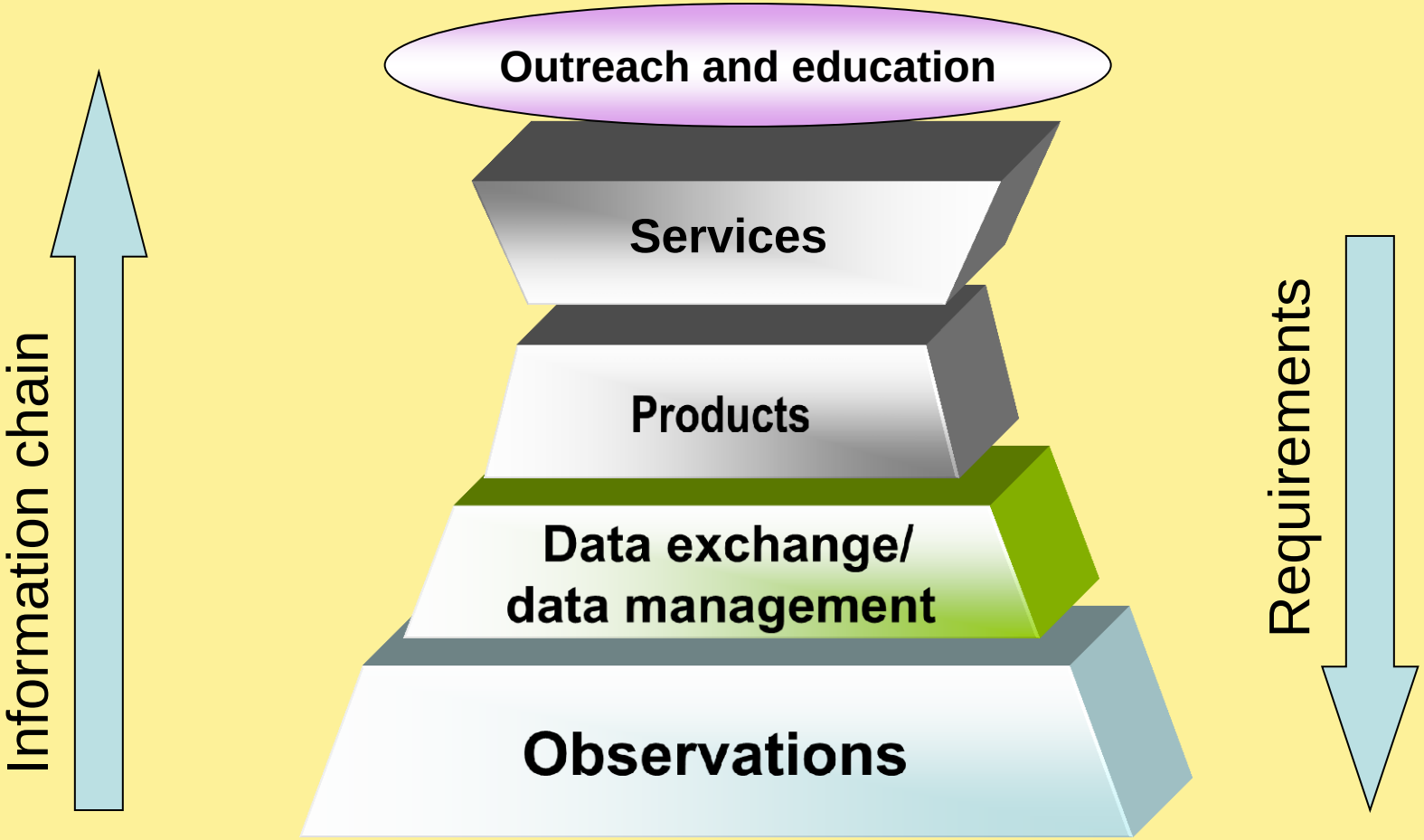
ICTSW intended activity areas



ICTSW activities / Space weather observations

- Review observation requirements and capabilities
  - Requirements database
  - Inventory of space-based observing capabilities
  - Statement of guidance (observation gaps and priorities)
- Advocacy for continuous key space weather observations
  - WMO Implementation Plan for Global Observing Systems
  - Mobilizing CGMS
  - Acknowledged in radio-frequency management discussions
- Not yet addressed
  - Interoperability (harmonizing measurement specifications, inter-comparison and calibration)

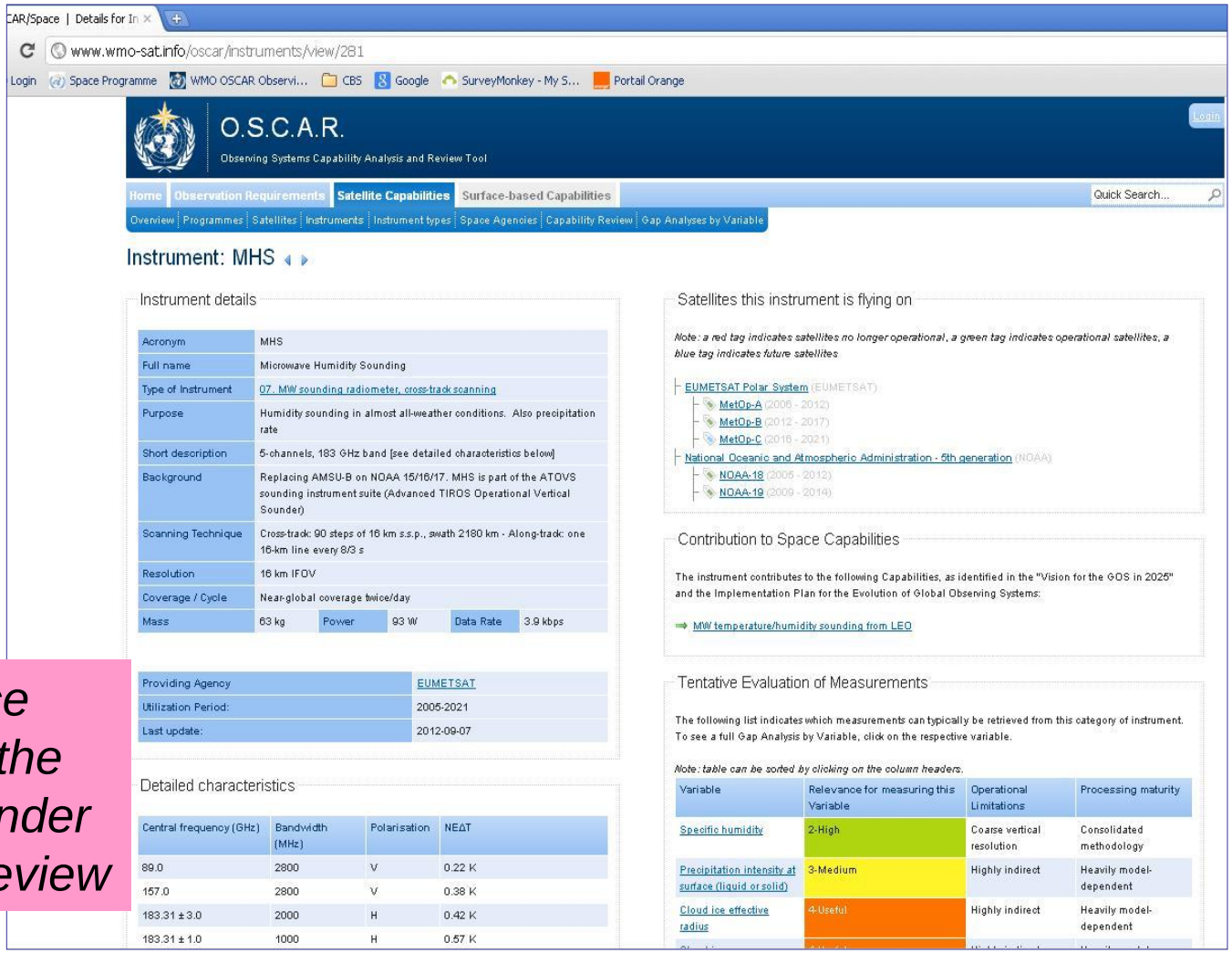
Rolling Review of (observation) Requirements . OSCAR database (http://www.wmo.int/oscar/)

Repository of observation requirements and capabilities

>500 satellites

>800 instruments

Note: the Space Weather part of the database is still under construction and review



OSCAR database (http://www.wmo.int/oscar/)

Measurement Timeline for *Solar EUV flux*

Definition:

Integrated EUV flux over the solar disk

Filter by Satellite or Instrument

Instrument	Relevance	Satellite	Orbit	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	203
EIT	3-fair	SOHO		X	X	X	X	X																
EXIS	2-good	GOES-R	137°W							X	X	X	X	X	X	X	X	X	X	X	X			
EXIS	2-good	GOES-T	137°W										X	X	X	X	X	X	X	X	X	X	X	X
SUVI	3-fair	GOES-R	137°W							X	X	X	X	X	X	X	X	X	X	X	X			
SUVI	3-fair	GOES-T	137°W										X	X	X	X	X	X	X	X	X	X	X	X
SEM/XRS	2-good	GOES-15	135°W	X	X	X	X	X	X	X	X	X	X	X										
SEM/XRS	2-good	GOES-14	105°W	X	X	X	X	X	X	X														
EXIS	2-good	GOES-S	75°W								X	X	X	X	X	X	X	X	X	X	X	X		
EXIS	2-good	GOES-U	75°W															X	X	X	X	X	X	X
SEM/XRS	2-good	GOES-13	75°W	X	X	X	X	X	X															
SUVI	3-fair	GOES-S	75°W								X	X	X	X	X	X	X	X	X	X	X	X		
SUVI	3-fair	GOES-U	75°W															X	X	X	X	X	X	X
SOLIST	2-good	Zond	TBD						X	X	X	X												
SXEUV	3-fair	FY-4C	86.5°E												X	X	X	X	X	X	X	X		
SXEUV	3-fair	FY-4E	86.5°E																		X	X	X	X
SXEUV	3-fair	FY-4B	105°E										X	X	X	X	X	X	X	X				
SXEUV	3-fair	FY-4D	105°E														X	X	X	X	X	X	X	X
SECCHI/EUVI	3-fair	STEREO (2 sats)	23.44 °	X	X	X	X	X																
EUI	3-fair	Solar Orbiter	25 °									X	X	X	X	X	X	X	X					
AIA	3-fair	SDO	28.5 °	X	X	X	X	X	X															
LYRA	2-good	PROBA-2	06:00 asc	X	X	X	X	X	X															
SWAP	3-fair	PROBA-2	06:00 asc	X	X	X	X	X	X															

ICTSW activities / Space weather data exchange

- Use of WIS for space weather data and metadata
  - Registration of initial set of products in WIS catalogue
  - Space weather centres becoming WIS Data Collection or Production Centre (DCPC)
    - NICT (proposed by Japan)
- Data format evaluation
  - RINEX/GTEX/IONEX, GNSS-RO data, ISES formats

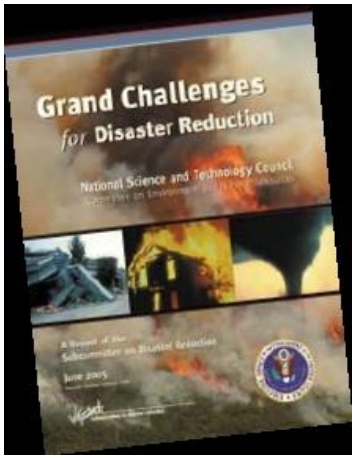
- Not yet addressed:
  - Review WMO metadata profile (ISO 19115)

ICTSW activities / space weather products and services

- Space Weather product portal
  - ✓ To inform potential users and demonstrate product availability
  - ✓ 40 « product collections » in 10 product categories

- Civil aviation : response to new ICAO requirements
  - Extension of the meteorological information coordinated by WMO

- Disaster risk management
  - Space weather increasingly recognized in national risk registers
  - Working on « best practices » for severe space weather warnings



- Other applications and services (GIC, GPS..): still to be addressed

CGMS

Coordination Group for Meteorological Satellites (created in 1972)

- Satellite agencies (operational or R&D) operating weather/climate/oceanographic missions in support of WMO or UNESCO/IOC programmes, + WMO, IOC
  - CMA, CNES, CNSA, ESA, EUMETSAT, IMD, JAXA, JMA, KMA, NASA, NOAA, Roscosmos, Roshydromet
- Scope:
  - Exchange technical information
  - Harmonization of mission parameters for interoperability (standards, best practices)
  - Continuity, complementarity, mutual back-up, through cooperative mission planning

CGMS and Space Weather

- Many meteorological missions of CGMS Members are flying space weather payload

- CGMS *is considering* to play an active role to support continuity and integration of space-based observations for operational Space Weather products and services.
  - Technical harmonization
  - Cooperative mission planning to ensure continuity

- Proposal to be discussed next May

Conclusions

Expected benefits of WMO's involvement

- WMO's experience and procedures (observation, information, warning systems) enable leveraging the technical coordination initiated by ISES

- WMO intergovernmental framework will facilitate international commitments by Members for long-term provision of services

- Integration/synergy can develop with meteorological information delivered to key users (Aviation, emergency managers, energy production and transport..)

Perspectives

- Complementary international initiatives
  - ISES, COSPAR, ILWS, CGMS, UN COPUOS

- ICTSW initial activities demonstrate relevance and usefulness of the WMO framework to enhance and coordinate operational space weather activities

- Real breakthrough requires more focused action
  - Long term continuity/interoperability of key observations
  - Best practices for severe event warnings
  - Space weather scales and forecast verification
  - Data sharing policy and protocols
  - Aviation and other applications

➢ Stronger involvement of WMO in space weather will be discussed at upcoming Council and Congress

WMO OMM

Thank you !

ICTSW Terms of Reference

Inter-Programme Coordination Team on Space Weather

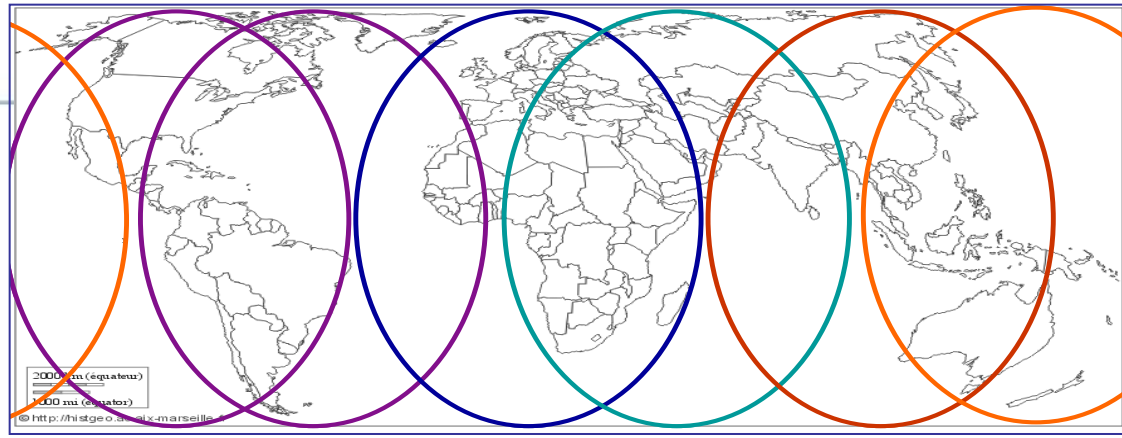
- Integration of Space Weather **observations,** through review of space- and surface-based observation requirements, harmonization of sensor specifications, monitoring plans for Space Weather observation;
- Standardization and enhancement of Space Weather **data exchange and delivery through the WMO Information System** (WIS);
- Harmonized definition of **end-products and services**, including e.g. quality assurance guidelines and emergency warning procedures, in interaction with aviation and other major application sectors;
- Encouraging the dialogue between the **research and operational** Space Weather communities.

Draft CGMS objectives for Space Weather

to support continuity and integration of space-based observations for operational Space Weather products and services.

- Keeping abreast of major user interests for operational Space Weather products and services and the related requirements that can be addressed by CGMS Members;
- Evaluating existing operational products and services in support of spacecraft operations, and recommending additional services as appropriate;
- Encouraging Space Weather monitoring missions either through dedicated satellites or through hosting space weather payloads aboard weather and climate monitoring satellites as technically appropriate;
- Supporting when relevant the dual use of sensors such as GNSS radio-occultation receivers that provide essential information for weather/climate and ionosphere;
- Fostering orbit coordination, sensor calibration and harmonization of operational sensors and data formats with a view to ensure interoperability and data consistency;
- Reporting on spacecraft anomalies and sharing the results of analyses;
- Pursuing global coordination of the operational Space Weather observing constellation, with a view to help to sustain future observing capabilities as done for terrestrial weather
- Encouraging complementarity, compatibility and possible mutual back-up in the event of system failure through cooperative mission planning,
- Communicating on socio-economic benefits of space weather prediction with policy makers, public, non technical community.

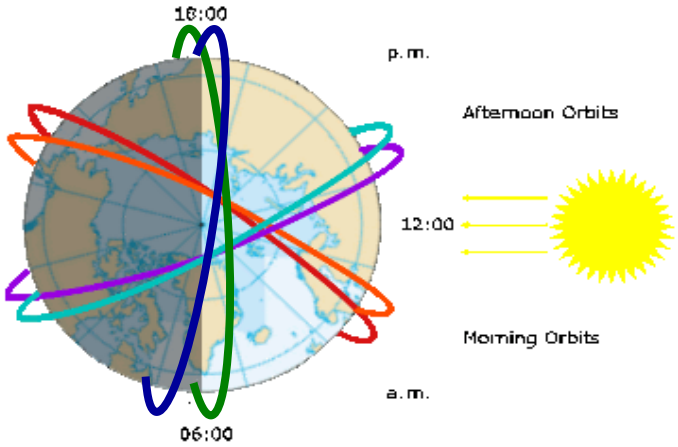
A WMO vision of the space-based global observing system



Geostationary component

- VIS/IR imagery
- IR hyperspectral
- Lightning imagers

Core sun-synchronous component imagery and sounding



Other missions/orbits:

- MW imagery
- Altimetry, scatterometry
- Radio-occultation
- Global Precipitation
- Atmospheric composition
- Earth Radiation Budget
- Multi-directional viewing IR imager
- Space weather (Solar, particles, space environment)

WMO'interest in Space Weather (1)

Space Weather affects meteorological / climate activities

- Impact on radio-communications
- Impact on meteorological satellites
- Effect on climate to be further investigated
- Coupling between ionosphere and neutral atmosphere models